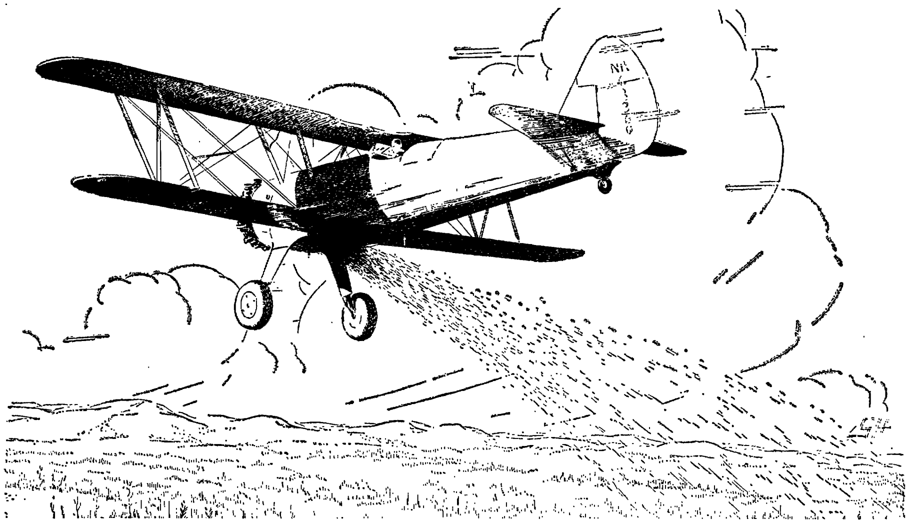

What Do We Plant?

FIRST THE SEED, THEN THE TREE

PAUL O. RUDOLF

IN THE United States more than 600 species of woody plants are useful for conservation planting, and some 75 million acres are in need of reforestation. For that, more than 100,000 tons of forest seeds will be needed. We should therefore know all we can about forest seeds—where they are borne, how often good crops come, when seeds are ripe, when is the best time to collect, how to clean them, how to store them, how to obtain prompt germination, how good they are, and what their origins are.

SEEDS DEVELOP from flowers. The floral organs are the stamens and the pistils, which produce the sperm, or male cells, and the egg, or female cells, which, when united, produce the seed. Some trees and shrubs have bisexual, or perfect flowers. Many, however, have stamens and pistils borne in separate flowers, either on the same plant or on separate plants. Others have both perfect and unisexual flowers on the same plant. A knowledge of these habits helps the seed collector to know what trees are likely to produce seeds and also what crop to expect from the abundance of blossoms.

A typical tree seed consists of an embryo, usually embedded within an endosperm (sometimes very thin or even absent), all enclosed in one or two seed coats. The embryo is a complete plant in miniature. The endosperm contains food reserves that become available for germination and early growth. The seed coat protects the embryo from injury before germination.

Tree seeds range in size from the powderlike rhododendron seeds to the large black walnuts. They differ greatly also in shape, color, and other characteristics. From the standpoint of col-

Above: A onetime Navy plane is used to seed white pine on burned-over forest lands in Maine.

lection and extraction, however, seeds fall into three groups:

1. True seeds readily extracted from dry fruits. Included in this group are trees whose seeds are borne in cones (fir, hemlock, larch, pine) or in fruits that split open, such as pods (honeylocust, locust, yellowwood), or in capsules (e. g., the fremontia, poplar, willow). Commercial seed is almost always the true seed.

2. Dry fruits with seeds surrounded by a tightly adhering fruit wall. Included are species whose seeds are borne in achenes (clematis, cliffrose, eriogonum), the nuts (chestnut, filbert, oak), and samaras, or key fruits (ash, elm, maple). Because it is hard to do so, seeds of this group are seldom extracted from the fruits. For all practical purposes the entire fruit is the seed.

3. Seeds of fleshy fruits. Included are species whose seeds are borne in accessory fruits (buffaloberry, wintergreen), aggregate fruits (raspberry), the berries (barberry, currant, honeysuckle), the drupes (cherry, dogwood, plum, walnut), multiple, or collective fruits (mulberry, Osage-orange), or pomes (apple, pear).

To supply the needs of the seed trade and reforestation, large quantities of tree seeds must be collected, extracted, and stored every year.

In scouting out supplies, the seed collector should keep eight points in mind:

1. The parent plants should be of desirable form and development.

2. Trees whose crowns receive light from above and the sides usually produce the bulk of the seed crop.

3. The flowering habit determines which trees will produce seeds and the part of the crown in which they are borne.

4. Estimates based on actual count of fruits on representative trees or on small sample plots well distributed over the collecting area are most reliable.

5. "Tree seed farms," set aside in mature stands of particularly good development or plantations of known good seed source, which produce seed in reasonable abundance, will provide desirable local collecting areas.

6. The tree seed-crop reporting services, available in some regions, tell the collector where good local crops are.

7. The soundness of seeds in individual localities, or even on individual plants, should be tested.

8. Next year's potential crop can be estimated from the number of first-year fruits for such trees as the pines, black oaks, and others which require 2 years to mature their fruits.

Ripeness of the seed and the length of time it may remain on the plant or on the ground without deterioration or injury determine the time of collection. Collectors usually judge the ripeness of fruits by their general appearance, color, degree of "milkiness" of the seed, hardness of the seed coat, their attractiveness to animals, or some combination of these factors. For some pines, ripeness can be determined more accurately by the floatability of freshly picked cones in motor oil, kerosene, or other liquids.

The exact time for starting seed gathering must be determined for each species in each locality each year. However, the general season in which to make collections is known for a great many species, some of which are:

Spring: Berlandier ash, river birch, cottonwoods, elms (except Chinese), red maple and silver maple, poplars, and the willows.

Summer: Bigcone-spruce, cherries, Douglas-fir, elders, alpine larch, magnolias, red maple, mulberries, Siberian pea-shrub, plums, serviceberries, California sycamore.

Fall: The ashes (except Berlandier), beeches, bigcone-spruce, birches (except river birch), boxelder, catalpas, cherries, Douglas-fir, Chinese elm, firs, hickories, junipers, the larches (except alpine), magnolias, maples (except the red and silver), oleasters, Osage-orange, pecan, most pines, plums, spruces, sycamores, walnuts.

Winter: Ashes (except Berlandier), yellow birch, the boxelders, catalpas, Osage-orange, black spruce, Norway spruce, sycamores, walnuts.

Any season: Aleppo pine, bishop pine, jack pine, lodgepole pine, Monterey pine, pond pine, sand pine.

Forest seeds commonly are collected from standing trees. Most tall trees must be climbed and the fruits or seeds detached by hand picking, by cutting them off, or by knocking them off. In hand picking, the fruits usually are placed in containers. If the fruits are cut or knocked off, they are usually caught in sheets spread below. Seeds usually are hand-picked or flailed from small trees or shrubs without climbing them.

It is usually cheaper to collect seeds from felled rather than from standing trees. The collector must, however, gather seeds only from trees cut after the fruits have begun to ripen.

Twenty or thirty years ago conifer cones frequently were gathered from squirrel hoards in the Lake States and the West. This is still done to some extent. However, seed collection from rodent caches is of limited usefulness because the parent trees are unknown, hoards are difficult to find consistently, and few species are included. Some successful collectors gather squirrel-cut cones from the ground.

Seeds or fruits are gathered from water surfaces or from drifts along the shores for a few tree species, such as baldcypress and some of the willows.

Fruits should be taken to the extraction point soon after collection. Fleshy fruits should neither be crushed nor dried for very long. Others should be spread out and dried partially before shipment.

To PREVENT spoilage, to conserve space and weight in the shipment and storage, and to facilitate handling and sowing, seeds of many species must be separated from the fruits and cleaned of fruit parts and debris.

Seeds are separated from the fruits by drying, threshing, depulping, or cleaning procedures such as fanning and sieving.

The simplest method of drying is to spread the fruits in shallow layers so that there is free circulation of air across and around each fruit. Where the climate is damp, or the quantities of fruit great, drying is usually done under a roof.

Artificial heat is necessary to open some cones readily. Artificial drying ordinarily is done in special kilns which aim to provide the highest dry heat that the seeds can stand without injury. Two general types of kilns are used for extracting seeds from cones: The simple convection and the forced-air. The former has long been in use; the latter has been developed since 1934. Newly developed in Canada is a kiln using batteries of infrared lamps.

Convection kilns depend upon the natural rise of heated air through cones spread on trays placed directly above the source of heat. Forced-air kilns are more complicated. Heat and humidification are supplied by steam, and fans provide forced circulation of the warm air. Temperature and the humidity are controlled automatically by an electrically operated recorder-controller. Forced-air kilns are more efficient than convection kilns. For example, it takes from 24 to 72 hours to extract seeds from red pine cones in convection kilns as compared to 5 hours in forced-air kilns. However, forced-air kilns are more expensive and require skilled men to install and operate them. The infrared kilns give promise of efficiency and relative cheapness and ease of operation.

Upon their removal from the kiln, cones are run through tumblers—revolving boxes or drums with screened sides—to shake out the seeds.

The seeds of many dry fruits must be separated from the bunches, pods, or capsules in which they grow. The simplest methods are flailing or treading under foot. Sometimes agricultural machinery can be used. Frequently, however, special apparatus is necessary for fully efficient extraction. Two

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types have proved widely useful, a macerator developed by the Forest Service, and a hammer mill. Either can produce several hundred pounds of clean seeds a day.

Some small fleshy fruits are dried whole. However, the seeds of most fleshy or pulpy fruits must be extracted promptly to prevent spoilage. Small lots can be cleaned by hand, by treading in tubs, or by rubbing through hardware cloth with hand brushes and water from a hose. Food choppers, concrete mixers, feed grinders, cider mills, wine presses, and restaurant potato peelers have been used for removing seeds from fleshy fruits, but none of these are as widely applicable as the Forest Service macerator or the hammer mill. Mulberries, chokecherries, or Osage-orange fruits, which require mashing and soaking before they can be run through the macerator, should not be allowed to ferment.

Seeds of several species, such as elm, maple, and oak, require no extraction, but need merely to be freed of chaff or trash. Often dried, without extraction, are some of the small fleshy fruits such as the chokecherries, elders, hollies, manzanitas, mountain-ashes, Russian-olives, and viburnums.

Methods of seed extraction commonly used for several species are:

Air or kiln drying: The arborvitaes, baldcypress, bigcone-spruce, ceanothuses, chamaecyparises, chestnut, chinquapins, cypresses, Douglas-fir, elms, eucalyptus, firs, hemlocks, California incense-cedar, larches, pines, poplars, common prickly-ash, redwood, spruces, sweetgum, willows.

Kilns necessary: The Aleppo pine, bishop pine, jack pine, lodgepole pine, Monterey pine, pond pine, sand pine. (The cones remain unopened on the trees for several years in all these species.)

Threshing or screening: Acacias, alders, baccharises, beeches, catalpas, Kentucky coffeetree, filberts, fremontias, hickories, honeylocusts, American hornbeam, common lilac, locusts, Siberian pea-shrub, eastern redbud, the rhododendrons, silktree, sourwood, sumacs, walnuts, witch-hazel.

Depulping: Apples, aralias, barberries, blackberries, buffaloberries, lilac chaste-tree, the cherries, cotoneasters, creepers, elders, grapes, hollies, honeysuckles, black huckleberry, common jujube, junipers, red mahonia, manzanitas, mountain-ashes, the mulberries, Osage-orange, common pear, common persimmon, plums, European privet, raspberries, meadow rose, sassafras, common sea-buckthorn, serviceberries, silverberry, snowberries, western soapberry, common spicebush, tupelos, viburnums, yews.

Cleaning methods: Apache-plume, ashes, birches, antelope bitterbrush, the elms, hackberries, eastern hophornbeam, common hoptree, the lindens, mountain-mahoganies, oaks, Carolina silverbell, tanoak, common winterfat, yellow-poplar.

Cleaning is sometimes necessary. For better storage and handling, seeds of many species must be cleaned of chaff, trash, adhering fruit parts, or empty seeds, after separation from the fruits. Sometimes cleaning is combined with extraction and often a combination of methods is required to clean the seeds. Most of the conifer seeds, for example, must be both dewinged and fanned.

Conifer seeds may be dewinged by hand rubbing, beating or trampling in sacks, or moistening and raking. Large-scale dewinging is usually done in machines, which tumble the seeds against stiff brushes, or in a macerator. Such machines must be used and adjusted carefully or much of the seed will be injured.

Often seeds can be cleaned satisfactorily by running them through screens, either dry or with running water. Often two screens are used in series, one with a mesh large enough to pass the seeds but hold back larger objects, and a second with a mesh small enough to hold the seeds but to pass smaller material.

Fanning is the principal means of removing wings or light chaff from many kinds of seeds. Sometimes empty seeds also are fanned out. Small lots can be cleaned by passing them from one container to another in the wind or in front of a fan. Large lots usually are run through standard agricultural seed fanning or cleaning mills. Unless fanning is done skillfully, either too much debris will remain or too many good seeds will be blown out.

Seeds of most pulpy or fleshy fruits can be cleaned most effectively by flotation in water. Sound seeds usually sink, whereas poor seeds, skins, and pulp either float or sink more slowly. Freshly gathered acorns often are separated from the cups and weeviled fruits by flotation in water. Loblolly pine seeds can be cleaned better by flotation in water than by fanning. Prompt drying after such wetting is essential.

To determine the amount of fruit needed for specific sowing or market requirements, it is necessary to know the extraction factor.

The amount of cleaned seeds produced per 100 pounds of fruit as usually collected ranges from 30 to 50 pounds for many species, and may range from 1 to nearly 100 pounds, as shown below:

One to five pounds: Apples, arborvitaes, red chokeberry, cucumbertree, golden currant, Douglas-fir, firs, hemlocks, honeysuckles, black huckleberry, California incense-cedar, inkberry, the larches, common lilac, mountain-ashes, the mulberries, Osage-orange, common pear, pines, raspberries, serviceberries, common snowberry, spruces, mahogany sumac.

Six to ten pounds: Glossy buckthorn, silver buffaloberry, black chokeberry, the elders, firs, honeysuckle, mountain-holly, western snowberry, skunkbush sumac, sweetfern, sweetgum, American sycamore, yellow-poplar.

Eleven to twenty pounds: Japanese barberry, bearberry, chamaecyparises, cherries, devils-walkingstick, elders, euonymuses, riverbank grape, shellbark hickory, pawpaw, Siberian pea-shrub, common persimmon, plums, redwood, Russian-olive, common sea-buckthorn, common spicebush, sugar sumac, common winterberry.

Twenty-one to forty pounds: Ailanthus, apricot, Japanese barberry, American beech, boxelder, most buckthorns, butternut, the gum bumelia, catalpas, cherries, Kentucky coffeetree, Virginia creeper, desertwillow, dogwoods, American filbert, fringetree, shagbark hickory, shellbark hickory, American holly, honeylocust, eastern hophornbeam, junipers, common jujube, locusts, mountain-mahoganies, common persimmon, eastern redbud, Russian-olive, common sea-buckthorn, silktree, western soapberry, smooth sumac, staghorn sumac.

Forty-one to sixty pounds: Ailanthus, indigobush amorpha, baldcypress, boxelder, Kentucky coffeetree, desertwillow, elms, European filbert, mockernut hickory, Norway maple, sugar maple, oaks, pecan, Fremont silktassel, smooth sumac, black walnut, little walnut, southern waxmyrtle.

Sixty-one to eighty pounds: Ailanthus, ashes, boxelder, lilac chaste-tree, bitternut hickory, mockernut hickory, pignut hickory, lindens, sugar maple, Tatarian maple, oaks, pecan.

Eighty-one to one hundred pounds: Ailanthus, bitternut hickory, pignut hickory, black maple, red maple, sugar maple, oaks, laurel sumac.

Storage varies considerably. Forest seeds seldom are sown immediately after extraction and cleaning. Commonly they are extracted in the fall and held over winter. Often, too, they must be held for several years because some species produce good crops infrequently. In either case the seeds should be stored so as to maintain high viability. For some species this is a simple matter; for others it is quite difficult, and for many, suitable storage practices are not yet known.

The simplest and oldest method of storage is to hold the seeds at air temperatures either in sacks or, preferably, in sealed containers. Storage may be at room temperatures, in cool cellars, or frequently in special seed-storage sheds. Seeds of many species can be kept for one or more years in such sheds, but for longer periods cold storage is necessary.

Seeds of many woody plants keep well at temperatures between 33° and 50° F. Before storage, seeds of most conifers should be dried to a moisture content below 10 percent of oven-dry weight. Seeds of the oaks, hickories, and silver maple, however, should be kept above 35-percent moisture content, and those of southern magnolia should not be allowed to dry at all. Proper cold storage requires a refrigerator or cold room in which temperatures can be held nearly constant. Sealed containers maintain the right moisture content and are best for such storage.

Many of the nuts and some other seeds often can be stored for a few months by mixing them with one to three times their volume of moist peat moss, sand, or chopped sphagnum moss, and placing them in a refrigerator or holding them over winter in the ground under a mulch. Sometimes fall sowing is used instead.

The short-lived seeds of the poplars can be kept fairly well for several months in sealed containers from which much of the air has been exhausted by suction pumps, or in which the relative humidity of the air is less than 20 percent. So far, however, vacuum storage has been attempted on a laboratory scale only.

Under proper storage, seeds of most trees can be kept viable for 5 to 10 years and that of some species has been kept for several decades. The best storage methods known for several species follow:

Dry, cold storage in sealed containers: Apples, arborvitaes, ashes, barberries, bigcone-spruce, birches, antelope bitterbrush, blackberries, silver buffaloberry, ceanothuses, lilac chastetree, the cypresses, Douglas-fir, elders, elms, firs, riverbank grape, hackberries, hemlocks, honeylocusts, common hoptree, black huckleberry, junipers, larches, black locust, maples (other than silver), the mountain-ashes, oleasters, Osage-orange, pines, some poplars, common prickly-ash, raspberries, eastern redbud, redwood, sassafras, giant sequoia, the snowberries, spruces, sumacs, sweetgum, witch-hazel, yellow-poplar.

Moist, cold storage: Beeches, buckeyes, chestnut, chinquapins, filberts, hickories, silver maple, oaks, tanoak, walnuts, yews.

At air temperatures: Acacias, Kentucky coffeetree, eucalyptus, fremontias, common lilac, lindens, common pear, the Siberian pea-shrub, European privet, meadow rose, fourwing saltbush, the common sea-buckthorn, common winterfat.

Under partial vacuum: Some poplars.

Pretreatment is sometimes required. Seeds of some trees and shrubs germinate quite promptly. Those of many, however, often fail to sprout even when exposed to suitable conditions of temperature, moisture, oxygen, and light. Such seeds are called dormant, and special treatment is required to induce germination.

There are two main causes of seed dormancy: (1) An impermeable or hard seed coat which prevents water and oxygen from reaching the embryo, or sometimes prevents the embryo from breaking through even though water has entered; and (2) internal conditions of the embryo or stored food. Many kinds of seeds have only one kind of dormancy, but there are many others which have double dormancy.

To overcome seed-coat dormancy, seeds usually are subjected to one of the following pretreatments: (1) Soaking in concentrated sulfuric acid (usually from 15 to 60 minutes); (2) scarifying the seed coats with abrasives; or (3) soaking in hot water (usually at a temperature of 170° to 212° F.) for about 12 hours as it gradually cools.

Treatments used to break internal dormancy are: (1) Cold stratification, in which the seeds are placed in moist sand, acid granular peat, or chopped sphagnum moss and held at 32° to 41° F. for 1 to 4 months; and (2) chemical treatment, in which the seeds are soaked in such materials as thiourea or exposed to fumes of such substances as ethylene chlorhydrin. The chemical treatments have been largely confined to experimental use.

To overcome double dormancy, the seed coat must be made permeable and the embryo or stored food induced to undergo the changes necessary for germination. Sometimes cold stratification is sufficient, but more often soaking in hot water, acid treatment, scarification followed by cold stratification, or warm followed by cold stratification is necessary. Double dormancy can often be broken by sowing the seed soon after collection in the late summer and early fall.

Out of 444 species of tree and shrub seeds studied, 33 percent were nondormant, 7 percent had seed-coat dormancy, 43 percent had internal dormancy, and 17 percent had double dormancy. A single species may have both dormant and nondormant seeds, or more than one kind of dormancy.

Typical species with dormant seeds:

Seed coat dormancy: Acacias, amorphas, Dahurian buckthorn, feltleaf ceanothus, the hairy ceanothus, Monterey ceanothus, Kentucky coffeetree, honeylocusts, black huckleberry, locusts, mesquite, common persimmon, silktree, western soapberry, sumacs (except skunkbush).

Internal dormancy: Alders (except European), the ailanthus, apples, most ashes, baldcypress, barberries, beeches, bigcone-spruce, birches (except river), antelope bitterbrush, American bittersweet, buckeyes (except California), alder buckthorn, glossy buckthorn, cascara buckthorn, buffaloberries, lilac chaste-tree, cherries, American chestnut, chokeberries, creepers, currants, flowered dogwood, devils-walkingstick, Douglas-fir, euonymuses, filberts, firs, fringetree, gooseberries (except roundleaf), riverbank grape, hackberries, hemlocks, hickories, hollies, honeysuckles, eastern hophornbeam, common hoptree, American hornbeam, junipers, most larches, common lilac, Pacific madrone, magnolias, most of the maples, the European mountain-ash, mountain-laurel, the mulberries, bitter nightshade, black oaks, oleasters, pawpaw, common pear, most pines, plums, common prickly-ash, European privet, sassafras, serviceberries, common sea-buckthorn, Fremont silktassel, Carolina silverbell, common spicebush, spruces (except the western white), sweetgum, sycamores, common trumpetcreeper, tupelos, viburnums, walnuts, southern waxmyrtle, checkerberry wintergreen, yellow-poplar.

Double dormancy: Bristly aralia, black ash, blue ash, European ash, bearberry, most ceanothuses, cotoneasters, most dogwoods, elders, fremontia, the panicled goldenrain-tree, downy hawthorn, black jetbead, some junipers, common jujube, the lindens, manzanita, Amur maple, American mountain-ashes, the mountain-holly, Osage-orange, Digger pine, Swiss stone pine, whitebark pine, raspberries, eastern redbud, meadow rose, wild-sarsaparilla, snowberries, skunkbush sumac, witch-hazel, yellowwood, yews.

Seed quality largely governs the rate at which seeds should be sown to produce a certain number of good seedlings. Tests can disclose several of the fundamental characteristics of quality: Genuineness, purity, number of seeds to the pound, moisture content, and viability.

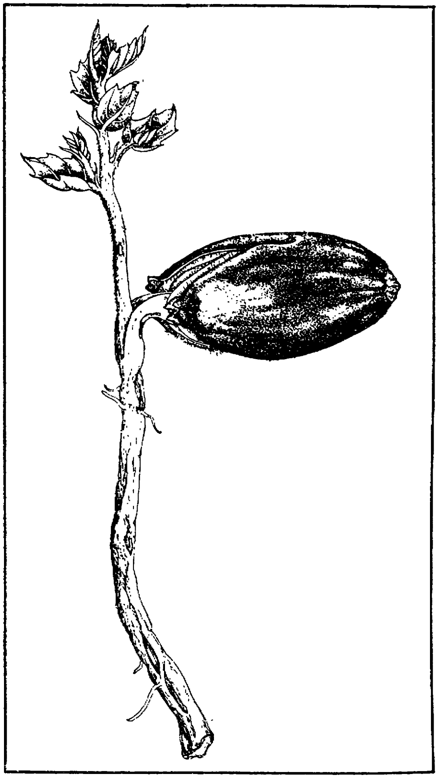
The sample tested should be truly representative of the entire lot. Representative sampling can be attained either by thorough mixing of the entire seed lot before sampling, or by drawing a number of small subsamples of equal size at random from different parts of the lot in proportion to the quantity of seeds in each part. The number of seeds required for a germination test seldom should be less than 400, tested separately in four equal parts. For lots larger than 100 pounds, from 800 to 1,000 seeds should be used.

Genuineness is determined by comparing a representative sample of the seed lot under test with samples of known identity. Purity commonly is expressed as the percentage by weight of clean whole seeds true to species in a sample containing seeds and mixed impurities. The number of seeds per pound is obtained by careful weighing of a counted number of seeds. It is usually expressed in two ways: The number of clean seeds per pound of the sample as received and the number of clean seeds per pound of pure seeds. Moisture content usually is expressed as a percentage of the oven-dry weight of the seeds after commercial cleaning, but not on a pure seed basis.

Viability, or the percentage of seeds capable of germinating when exposed to the most favorable conditions, is determined directly by germination tests or indirectly by cutting tests, the growth of excised embryos, flotation, biochemical staining of embryos, or measurements of enzyme activity. The indirect methods give quicker results, but they are seldom as reliable as direct germination tests.

Germination tests usually are made in flats, porous clay pots, or greenhouse benches filled with fine sand, acid peat (sometimes used as compressed mats), or sphagnum moss; or in germinators on porous plates, blotters, filter paper, or agar. Sand, peat, or sphagnum moss are preferred as giving results closer to germination in the nursery. Carefully counted numbers of seeds, pretreated where necessary, are sown on the surface of peat mats or at controlled depths in sand, moss, or peat flats. Small seeds are sown shallow; larger seeds deeper, as a rule.

The sand, peat, or other medium must be kept at a fairly constant moisture level. Air temperatures should be controlled closely. Many species germinate well at temperatures fluctuating from 68° F. at night to 86° during the day; some do just as well at constant temperatures of 70° or 75°;



Oak seedling. The two plump seed leaves packed with food remain inside the acorn.

others need temperatures that fluctuate from 50° (night) to 77° (day); and some germinate best at temperatures between 40° and 50°. The needs of each species must be known and supplied for best results. Light is not necessary for germination of most tree seeds, but aids that of some southern pines. Germination tests ordinarily are run for 30 to 60 days. Counts should be made every 2 or 3 days, and systematic records of results should be kept and made available to the seed user. Promptness of germination is almost as important to nurserymen as amount.

NURSERYMEN DETERMINE the rate of sowing from the laboratory tests as modified on the basis of their own experience. Nursery germination of tree seeds commonly is from 50 to 80 percent of laboratory germination. Since further losses normally occur after germination, the usable seedlings produced by a number of species usually run from 10 to 60 percent of the viable seeds sown. The following produce 10 to 15 usable seedlings for every 100 viable seed sown: European white birch, silver buffaloberry, Siberian crab apple, desertwillow, elms, Tatarian honeysuckle, European larch, common lilac, and Russian mulberry. Lilac chaste-tree, Japanese larch, and redwood yield 16 to 20 usable seedlings; Dahurian buckthorn, hackberries, Siberian larch, black locust, and nannyberry produce 21 to 30; the common jujube and Siberian pea-shrub, 31 to 40; and the baldcypress, pines, and spruces, 41 to 60.

THE SOURCE OF SEED is important. Forest trees and shrubs have evolved races within species. Each race is specially adapted to thrive under the conditions in which it has developed. Unless seeds of proper origin are used in forest planting, trees undesirable in vigor, form, or hardiness may result even though the right species has been used.

Studies started more than 100 years ago in Europe and about 35 years ago in the United States have shown that there are climatic races in about 30 North American and 35 foreign tree species. Doubtless many other trees and shrubs also have developed races. Comprehensive information is available for only five trees: Ponderosa pine and Douglas-fir from North America; and Scotch pine, Norway spruce, and European larch from Europe. Within these species the various races differ in rate of growth, stem form, leaf length, and color; the time that growth starts and stops; resistance to frost, drought, diseases, and insects; fruit and seed size; and wood quality.

Some forest trees, within areas of uniform climate, have even developed races particularly adapted to local site conditions. Furthermore, trees of the same species within an individual stand may display much hereditary variation in all the characteristics listed under climatic races. For these reasons seed collectors should use extreme care in selecting the stands and even individual trees from which they obtain seeds. They should try to have stands of desirable trees set aside as tree-seed farms to provide a continuous source of high-quality seeds.

In most countries of northern and central Europe rigid laws have been enacted to enforce the use of forest-tree seeds of suitable origin. In the United States no Federal legislation has yet been passed, but some dealers have provided information as to seed origin. The United States Department of Agriculture in 1939 adopted a forest-seed policy, stressing the use of local seeds, and some other agencies have followed suit.

ON THE BASIS of present knowledge, there are three general requirements that should be enforced either by voluntary action or regulation:

Seed collectors should be required to label their seeds accurately and adequately as to species, time of collection, and place of collection.

Seed dealers should be required to purchase only properly labeled seeds from collectors who are known to be reliable.

Users of seed or nursery stock should demand adequate information as to seed origin and should use only seeds of local origin or of proven adaptability to local conditions, or stock grown from such seeds.

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